Integration of Tillage, Fertility, and Crop Rotations in a Cropping System

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Abstract

In 1987, a long-term cropping systems study was initiated at the NDSU Carrington Research Extension Center (NDSU CREC). The study consists of three, four-year crop rotations with three replicates. Each crop in each rotation occurs in every year. Within each crop (main plot) in a rotation, four nitrogen (N) fertility treatments are imposed (sub-plots). N treatments are ammonium nitrate broadcast applied each spring to non-leguminous non-fallow plots at 0, 45, or 90 kg N ha^{-1} or as manure (M) applied at 179 kg ha^{-1} N the first spring of each four-year rotation to all. These treatments are imposed perpendicular to the three tillage systems, resulting in 12 sub-sub-plots within each crop. The tillage systems are conventional (T), minimum tillage (M), and no till (N). Hard Red Spring Wheat (HRSW) (*Triticum aestivum* L.) is the crop common to all rotations. Its grain yield, protein content, and test weight are significantly influenced by the crop rotation, tillage system, and N treatment.

Objectives

Investigate the effects of Cropping Systems on crop yield and quality, crop pest frequency and severity, and soil quality.

Introduction

There are numerous cash crops grown in North Dakota and the study is being used to compare the profitability and sustainability of eight crops in differing rotations, tillage, and N fertility.

Tillage treatments in the cropping system, (left to right) minimum tillage, no-till, and conventional tillage.

Materials and Methods

N fertility in the cropping system, 0 kg ha^{-1}, foreground, and 90 kg ha^{-1}, background.

The experiment is conducted at the North Dakota State University Carrington Research Extension Center near Carrington, North Dakota, on a Heimdal-Emrick loam soil. Within each 0.50 ha^{-1} main plot comprising crop, the four N fertility treatments are imposed strips perpendicular to the three tillage systems (Fig. 1). The tillage systems are conventional, minimum, and no till. The conventional tillage system uses at least three tillage operations (fall + spring) resulting in less than 30 percent residue cover after seeding. Minimum tillage systems generally rely on two tillage operations (non-inversion) resulting in greater than 30 percent residue cover after seeding. The no till has zero tillage other than disc openers on planter or drill resulting in greater than 80 percent residue cover after seeding. The crop rotations were designed to test varying crop types and water use intensities on crop yield and pests compared to the traditional crop rotation indicative to the area. The crop rotations for the 1999-2002 crop cycle are the traditional rotation HRSW /Sunflower (*Helianthus annuus* L.)/Barley (Hordeum vulgare L.)/Fallow (Rot 1), the alternating grass legume rotation HRSW /Soybean (*Glycine max* L.)/Durum (*Triticum turgidum* L.) /Field Pea (*Pisium sativum* L.) (Rot 2), and the compound or stacked rotation HRSW /Corn (*Zea mays* L.) /Soybean (*Glycine max* L.)/Canola (*Brassica napus* L.) (Rot 3).

Monthly Precipitation (mm) and 1961-1990 Average

Month	1999	2000	2001	2002	Avg
Apr	58.7	10.2	19.8	23.6	41.1
May	114.6	29.7	53.6	11.2	55.6
June	96.8	110.2	121.9	70.4	88.4
July	61.2	79.5	150.9	77.0	70.2
Aug	112.3	95.3	29.5	93.5	51.1
Sept	34.3	35.3	19.6	11.7	43.9
Total	477.9	360.2	395.3	287.4	350.3

Data taken from the annual reports vol 40 and 43.

Monthly AverageTemperatures (C) and 1961-1990 Average

Month	1999	2000	2001	2002	Avg
Apr	5.6	5.0	6.7	3.3	4.4
May	12.8	13.3	13.3	9.4	11.7
June	17.8	16.1	17.2	18.9	17.2
July	20.0	20.6	20.6	21.1	20.6
Aug	18.9	19.4	20.6	18.3	18.9
Sept	12.2	13.3	14.4	15.0	12.8
Avgs:	14.4	14.4	15.6	14.4	14.4

Data taken from the annual reports vol 40 and 43.

Results

Weather:
- 1999 had above normal precipitation (P) and average temperatures (T).
- 2000 had approximately normal P and average T.
- 2001 had above normal P and T.
- 2002 had below normal P and approximately normal T.

Year
- Year significantly altered HRSW grain yield (Fig. 2).

Crop Rotation
- Rot 2 (alternating grass legume crop rotation) produced significantly higher yield (Fig. 3).
- Different tillage systems produced significantly higher yields within each crop rotation (Fig. 4).

Tillage System
- The conventional tillage system produced significantly higher yield (Fig. 5).
- Significantly higher yield was achieved with different tillage systems among crop rotations (Fig. 4).

N Fertility
- The manure treatment produced significantly higher yield compared to other N treatments (Fig. 6).
- N fertility treatment produced significantly different yields among years (Fig. 7)

Conclusions

- Year drastically influenced yield.
- Crop rotation greatly influenced yield.
- Tillage system significantly influenced yield.
- N fertility dramatically influenced yield.
- There is no single tillage system by fertility treatment combination that produced significantly higher HRSW yield across crop rotations.

Figure 1. Main plot layout.

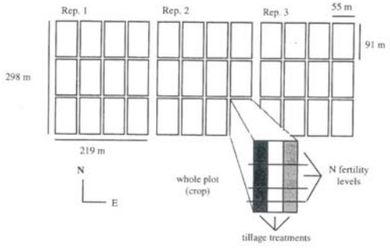


Figure 2. Mean HRSW yields for the 1999-2002 crop cycle.

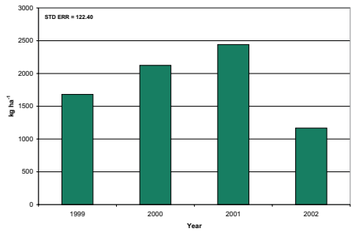


Figure 3. Influence of crop rotation on HRSW yield for the 1999-2002 crop cycle.

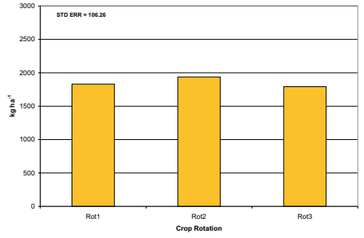


Figure 4. Influence of crop rotation and tillage on HRSW yield for the 1999-2002 crop cycle.

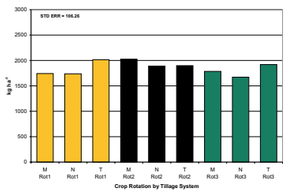


Figure 5. Influence of tillage on HRSW yield for the 1999-2002 crop cycle.

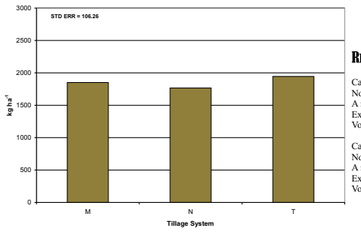


Figure 6. Influence of N fertilization on HRSW yield for the 1999-2002 crop cycle.

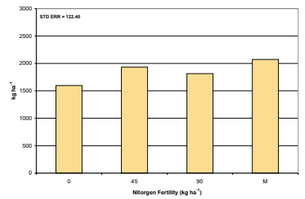
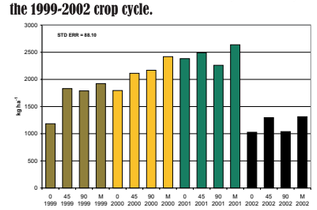


Figure 7. Influence of year and N fertility on HRSW yield for the 1999-2002 crop cycle.



N fertility treatments in corn, (front to back) 90, 0, 45 kg ha^{-1}, and manure.

References

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